The innocent mosquito? The environmental ethics of mosquito eradicatio

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Abstract: In any proposal for specicide, as represented by mosquito eradication, one must acknowledge that this involves a complex set of moral trade-offs. Taking it as given that the health burden of vector-borne diseases has to be reduced drastically, this chapter lays out the landscape of normative arguments that can be brought in the mosquito's defence. These, in turn, should be involved in deliberations about whether such large-scale eradication practices can be morally justified. In favour of mosquito protection, several (but not exhaustive) kinds of arguments are presented based on individual mosquito's moral standing, the value of each species, concerns about hubris and risks, and questions about preferable alternatives. At the same time, this chapter also inquires whether the conflict between humans and mosquitos can be framed as a matter of self-defence—attributing to humans a right to defend themselves. A morally important distinction here is that the mosquito is merely instrumentalized by the disease that it carries which is the real motive of self-defence, showing that mosquitos are innocent in several senses of the term. Taking all these different moral considerations seriously leaves us with an awareness that the eradication of these species cannot be treated lightly

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13

THE INNOCENT MOSQUITO?

The environmental ethics of mosquito eradication

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Who has not swatted at least one mosquito? Surely most people have crushed at least one mosquito on a hot summer evening and did not think that there could be anything morally wrong about stopping that nuisance. After all, diseases transmitted by mosquitoes are a major global health issue: malaria, dengue fever and Zika—to name a few—are diseases transmitted by mosquitoes, with substantial impact on the well-being of a large part of the world's human population. Some mosquito-borne diseases such as the West Nile virus are hosted by other animals before being spread to humans (that is, they are zoonotic diseases, like the 2020 coronavirus pandemic), thereby situating this global health problem in a web of interspecies entanglements. To address this proliferating problem, drastic means might be considered necessary, such as eradication, bringing to extinction an entire mosquito species that transmits diseases, or at least drastically diminishing their populations. Can such large-scale eradication practices be morally justified?

That is the question that I will focus on in this chapter with a specific focus on the eradication of entire vector species which is a broader aim than the elimination or control of a few populations of that species. Instead of providing arguments from within public health ethics on the problem of mosquito-borne diseases, this chapter rather looks through an environmental ethics lens to illustrate what can be said to plead the mosquito's case. The upshot in this "mosquito debate" is that we must acknowledge that in case of eradication something of moral relevance would be lost, even if we have good reasons to advocate such drastic methods: namely, mosquitoes matter. This chapter does not attempt a definitive answer or recommendation for action, but instead lays out the landscape of potential normative arguments. Importantly, the problem-framing influences what we perceive as morally salient features of a situation. If mosquito-borne diseases are considered to be borne out of a conflict of interests between humans and

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mosquitoes, then it needs to be kept in mind that the mosquitoes are "innocent" in several senses of the term as discussed later.

Environmental ethics is a field within moral philosophy that considers questions such as whether nature has a value that is independent of its usefulness to humans; or whether animals can be considered to be holders of moral rights. It is useful to briefly engage with some arguments from this literature in order to provide a picture as inclusive as possible, covering a range of issues that are relevant to environmental moral theorizing. Moreover, this picture is not complete, since I look at the problem only from a Western analytical philosophy perspective. Introducing arguments in favour of the mosquito does not mean that there are no good counterarguments and other considerations that might outweigh the mosquito's case. As we will see, also from an environmental ethics perspective, it is not always easy to justify the strong discomfort some may feel about different mosquito eradication proposals.

Of course, a full assessment of the mosquito problem would need much more detailed analysis than can be provided here, and many more nuanced questions regarding less drastic means than complete vector species eradication need to be asked, such as disease control by insecticide treated bed nets (ITN), or regarding the different means of disease eradication, in general, and the eradication of mosquito species, in particular. The discussion will rather remain at quite an abstract level. Regarding the *elimination* of mosquito populations in a specific area, for example, one could ask whether certain practices (such as spraying large areas with biological or non-biological agents) are morally preferable or inferior to other options (such as releasing genetically altered mosquitoes into an ecosystem) in addition to questions about feasibility, even if we would reach the conclusion that eradication of disease-carrying mosquito species was all-things-considered necessary. While the elimination or reduction of mosquito populations does not have to add up to species eradication and therefore these constitute distinct aims, it is also the case that different means of eradication or elimination need to be distinguished regarding whether they have *broad* adverse effects or constitutes means of "*target killing*" the vector species in question.

Three preliminary points can be made. First, the following considerations are based on the assumption that complete eradication of certain mosquito species might be possible in the near future (despite not being possible at the moment), leaving aside the question regarding which interventions this would entail. Second, eradication is the focus here as it constitutes the most "extreme" form of disease-control from the mosquito's perspective—although most of what follows is also applicable to deliberations about population control as well. Third, although a nuanced analysis would distinguish between reducing the disease burden and eliminating it completely, we shall simply assume that there are strong normative prerogatives for both of these goals.

The following discussion is divided into five sections. The first section sketches the broader "moral landscape" of the mosquito eradication and control question to identify a few important considerations that go beyond environmental ethics,

narrowly conceived. The second section shows how the lives of mosquitoes matter morally in themselves or as members of a species, while the third section discusses how the lives of mosquitoes might matter also indirectly in our moral deliberations. The fourth section is dedicated to the subject of how eradicating mosquito species constitutes a form of self-defence and whether this might constitute an appropriate framing of the disease-carrying mosquito conflict, with the last section summarizing the main points and offering some concluding remarks.

The moral landscape

The environmental ethics questions considered here are situated in the broader discourse of moral philosophy which includes other fields with important contributions to the issue of mosquito eradication, especially political philosophy and bioethics. Here there are four (not exhaustive) general issues that stand out.

For one, mosquito eradication and control require us to think about *legitimacy*. That is, who should decide about such interventions? In essence, this issue revolves around informed consent and political legitimacy. Matters of informed consent, as discussed in bioethics, account for the need of patients making voluntary decisions about their own medical treatment in clinical practice and medical research (see Manson and O'Neill 2007). Yet in this context it is more apt to speak of "group consent" (see Deplazes-Zemp 2018). Thus, field trials and other interventions on mosquitoes require the informed consent—or rather authorization via appropriate procedures—of the affected human communities in order to gain legitimacy (Meghani and Boëte 2018, Neuhaus and Caplan 2017), which leads also to the political dimension of legitimacy. Mosquito eradication projects are large-scale enterprises with effects that can transcend spatial and temporal borders to affect distant communities and future generations, involving inputs from national and international governmental and non-governmental agencies. This generates questions of political legitimacy (which is a contested area of debate) in terms of, for instance, the democratic authorization required to justify political power (see Buchanan 2002).

There is a second issue of *risk*, and the way it is embodied by different interventions which I will consider briefly in the third section. A complicated subject, risk is integral to any eradication and control proposal according to methods, aims and potential kinds of risks involved. It is precisely due to such risks that questions of legitimacy become especially salient.

A third issue that arises regards questions of *distributive justice*, since the burden of mosquito-borne diseases particularly affects the poor which, in turn, is linked to the uneven capacities of health services and relevant infrastructure (Greisman et al. 2019). There are also often special risks for pregnant women and children who catch a mosquito-borne disease. Such an unequal global distribution of the burden of disease can possibly be exacerbated by other influences such as climate change (WHO 2017). Accordingly, a global health justice lens then introduces a

range of questions about such issues as the fair distribution of costs of and access to interventions, and duties to aid the most affected. Moreover, the interactions between different dimensions of injustice—economic, health-related and environmental—need to be kept in view.

Finally, and as the fourth issue, insofar as steering and monitoring people's behaviour constitute important elements of an eradication strategy, then we must be sensitive to questions about how they interfere with people's autonomy and right to privacy (Greisman et al. 2019). In light of these issues, we must acknowledge that the eradication of certain mosquito species would be of significant benefit (at least in the short term) to many people living in areas where mosquitoes are endemic. The dramatic impact mosquito-borne diseases have on the lives of many humans constitutes the main—and weighty—reason for eradication due to the fundamental interests to life and health at stake. Since several other chapters in this volume are already dedicated to the human dimensions of this ethical problem, we shall turn to other issues. As a consequence, we need to differentiate between what would be all-things-considered justified and what would be justified from the incomplete environment ethics perspective that I am presenting here.

Why mosquitoes matter

The question of whether we should eradicate disease-carrying mosquitoes is a significant challenge for many environmental ethicists who are committed to biological conservation aims. Many ethicists will not be satisfied with simply dismissing the mosquito's place in the ecosystem as a "romantic notion" (compare, for instance, Fang 2010: 434). Moreover, amongst these are also ethicists with biocentric or ecocentric commitments who argue there are many more morally relevant attributes in nature than just sentience (such as in terms of the capacity to suffer pain). So, they will not be impressed by the possibility of a pain-free "specicide" (compare, for instance, Judson and Pugh in Bates 2016, and, in more detail, Pugh 2016). In the end, any comprehensive answer to the question about whether we should eradicate disease-carrying mosquitoes will involve a complex set of moral trade-offs. In favour of the protection of the mosquitoes in question, a combination of four different (but not exhaustive) kinds of arguments could be presented based on (1) caring about each *individual* mosquito, (2) the value of each *species*, (3) what eradication says about *our moral character* and (4) whether the potential benefits outweigh the *risks* of interventions. I address each of these issues in turn, starting with the first two in this section.

The moral considerability of each individual mosquito

As biocentrists will argue, focusing on sentience alone oversimplifies the moral landscape, because all living beings matter morally in themselves. That means that the life of each individual mosquito is morally considerable and

must be accounted for in our moral deliberations. As Paul Taylor phrased it, "[t]he biocentric outlook on nature … includes a certain way of perceiving and understanding each individual organism. Each is seen to be a teleological (goal-oriented) centre of life, pursuing its own good in its own unique way" (Taylor 1986: 44–45). From this perspective each individual mosquito matters in itself independent of whether humans consider it useful, harmful or beautiful.

This theoretical commitment entails that the well-being of even such dangerous creatures as *Aedes aegypti* must be acknowledged and integrated into our moral deliberations. Although this is the necessary conclusion of any biocentric position, it is also of course a contested idea. Putting it very crudely, critics who argue that this goes too far usually maintain that *either* only humans are morally considerable (Kant 1997, 1998) *or else* that non-human beings also have moral standing, but only if they exhibit some basic capacities such as in terms of awareness or an ability to suffer pain (Singer 1975, Regan 1984). Both perspectives exclude mosquitoes from the moral realm as beings that matter in themselves as—based on present knowledge—it is unlikely that they feel pain, for instance.

In contrast, others might counter that it seems convincing to attribute moral standing to individual mosquitoes—and that they therefore deserve consideration in eradication programs—but accounting for that standing would be so demanding on our actions that we should exclude them from our moral considerations nevertheless. Besides that such considerations feed into issues we will look at in the following sections, it is important to point out that being a holder of moral status (in terms of being morally considerable) is not enough to explain the full moral context that needs to be taken into account, and so does not sufficiently explain what we should and should not do. Living beings matter in themselves, but what is ultimately morally justifiable also depends on the contextual and relational features of the situation. If a biocentrist would be committed to declaring that harm ought not be inflicted on any being with moral status under any circumstances, this would not constitute a viable position. We can refuse to pick a specific flower in a field or to kill a specific spider in our living room, but we eat plants; insects die on our windshields. And beyond contextual and relational considerations (which always matter but on which theories diverge), different theories also provide different accounts of the relative weight of the moral status of a mosquito compared to that of other beings with moral status —if they deem mosquitoes morally considerable at all. Broadly speaking, the options are between egalitarian accounts, where all beings (but not all kinds of interests) matter exactly the same (Taylor 1986), and hierarchical accounts, where mosquitoes have less moral significance than, for example, sentient animals (Agar 2001), or else non-hierarchical accounts, in which the moral significance of different living beings is incommensurable which strongly emphasizes contextual and relational considerations (Wienhues 2020).

Even if moral standing is insufficient for safeguarding all mosquitoes even in situations that do not involve substantial public health considerations, the

minimum that this requires of us is to consider whether there are alternative means that are as good from a public health perspective that do not require such drastic actions that might harm such a large number of mosquitoes. Alternatives to mosquito eradication include, for example, vaccines, the reduction of mosquito breeding grounds or the improvement of healthcare and sanitary facilities which might create considerable public health benefits. If individual mosquitoes are morally considerable, then we have an additional reason for seriously considering disease-control interventions that cause less harm to mosquitoes than eradication campaigns might do.[1]

The moral value of each mosquito species

Besides the moral status and related inherent worth of an individual mosquito, we may also attach some kind of moral value to each mosquito *species* (which, in turn, is related to considerations about biodiversity) which is particularly relevant if we speak about species eradication. The instrumental value of a species refers to its current or potential usefulness for humans, for example in terms of what some call "ecosystem services."[2] Whether certain mosquito species have such instrumental value depends ultimately on empirical evidence about, for instance, their role in various ecosystems, and whether ecosystems could perform these functions if the species were removed. However, can a mosquito species also be conceived as non-instrumentally valuable?

Some think that this is the case. From such a perspective each disease-carrying mosquito species can indeed be attributed value that goes beyond its instrumental value, if it has any. Yet, there is a range of different positions that can be taken on this matter. Amongst other things, one's position on the value of species depends, on the one side, on what position on values one takes (such as debates between objective and subjective value accounts) and on the other side, on one's position regarding what constitutes a species (such as the debates about the ontological status of species).[3]

For example, a fairly common claim is that species hold some form of objective "natural historical" value (Rolston 1995, but compare Sandler 2012), which is a type of non-instrumental value.[4] Holmes Rolston III develops a bold version of the idea of natural historical value, arguing that each extinction is a kind of "superkilling" (1995: 523) because "a biological species is not just a class. A species is a living historical form … propagated in individual organisms, that flows dynamically over generations" (1985: 721). Such reasoning suggests that the human-caused loss of a species and its associated natural historical value is morally problematic and given that this constitutes an "objective" value it is independent from peoples' preferences. Here, people are not required to personally care about mosquitoes for them to be valuable in an objective natural historical sense.

Yet even Rolston, as a strong advocate of biodiversity conservation, argues that the "duty to species [not to cause their extinction] can be overridden, for

example with pests or disease organisms" (2001: 410). Thus, even if a mosquito species holds natural historical value, things do not look good for our mosquitoes. Moreover, the moral value of different species may be considered to be differently morally weighty. In terms of natural historical value, one consideration might be that a lack of distinctiveness of a species implies that it is not as valuable as another, recognizing that there are more than 3,000 mosquito species with differing degrees of distinctness around the world. Because only a small number of these mosquito species actually transmits diseases to humans, the case for protecting them based on their moral value needs to be supplemented with other considerations in their favour.

Adding context

Of course, considering the value of mosquitoes as either individuals or as species is neither sufficient for reaching a moral judgement for their protection, nor is it the only route for constructing an argument that speaks against their eradication. So far, we have only considered what matters morally (that is, has moral standing or value), but these considerations have to feed into normative theories (such as theories that focus on rights, utility or moral character). In this chapter I cannot give justice to the range of aspects different normative theories can bring to the subject of mosquito eradication and, thus, I will limit myself to mentioning just a few considerations that stand out (the points three and four mentioned previously)—starting with virtue ethics.

Hubris

To many people, the concern about hubris is an intuitive criticism to visions of mosquito eradication. Environmental virtue ethics is the most obvious lens for understanding this concern, because it puts emphasis on a person's moral character. In this context, the question that poses itself is whether eradicating entire species is compatible with being and acting as the kind of person that has internalized a range of different virtues (that is, excellent character traits). Of course, even here there is a large variety of theoretical accounts, all of which propose a range of environment-specific virtues such as humility or gratitude as central attitudes towards nature. What actions such theories justify depends, on the one side, on what they consider morally valuable, as discussed before, and on the other side on the content of the relevant virtues (Sandler 2016).

Context is very important for virtue ethics approaches. However, at first view at least, it seems that different environmental virtue ethics, including varieties that do not acknowledge the moral standing of individual mosquitoes, are at least sceptical of plans to eradicate several mosquito species. On the face of it, such plans appear hubristic by misrepresenting humanity's appropriate role in nature in addition to being epistemically hubristic by overestimating humanity's ability to control nature. That is problematic insofar as hubris is understood

as a vice, and insofar that such plans are incompatible with such virtues as humility in our actions and our stance toward the environment. Such concerns, of course, appear particularly pressing if one also presupposes a particular way of understanding humanity's place in nature that rejects the role of a master or a manager.

In terms of hubris and humility such an endeavour to eradicate mosquitoes appears to share similarities with other controversial human interventions in nature, such as plans to address climate change through geoengineering (Meyer and Uhle 2015) or genetic crop modification through biotechnology (Sandler 2004). Whether different accounts of environmental virtue ethics ultimately reject or justify such wide-ranging human interventions—including the eradication of disease-carrying mosquito species—involves taking into account all morally relevant contextual features, humanity's health burden being one of such crucial concerns.

Risks

A person who is not convinced by virtue-based perspectives might, however, think differently about risk-based arguments and still be inclined to favour a precautionary approach in light of the risks involved in any such intervention (even if done for purely human-focused reasons) when weighted against its potential benefits. Much recent work about ethics and disease-carrying mosquitoes are written from a public heath perspective and highlight this specific question of risk—usually linked to the importance of community engagement mentioned earlier—in light of the current development of gene drives for containing mosquito-borne diseases (Greisman et al. 2019, Patrão Neves and Druml 2017, Resnik 2014, Resnik 2017).

Gene-drive systems, as technologies of genome editing, are developed, for example, as means for eradicating mosquito species or else creating resistances to pathogens (such as a virus) in a target population of mosquitoes. For instance, Jonathan Pugh (2016), who does not consider mosquitoes to be morally considerable in themselves, does not find the "hubris objection" convincing while discussing gene-drive technologies potentially being used on disease-carrying mosquitoes as a means of eradication. Still, he argues that a better understanding of the potential effects and success of mosquito eradication will be important to make well-informed moral decisions. Indeed, Pugh is right when claiming that "epistemic humility" does not involve the dismissal of biotechnology based on it having *some* risk (Pugh 2016: 580). Yet, the potential irreversibility of gene drives, for example, is definitely a risk to take into account. Even by relying on solutions less technical than gene drives, the eradication of a species by more "conventional" means carries a risk for ecosystems and may be irreversible (when putting the controversial possibility of "de-extinction" with technological solutions aside). Accordingly, one might still be inclined to favour the precautionary principle in light of the risks involved in any intervention—even ones carried

out for purely human-focused reasons—which are intertwined with a range of empirical questions.[5]

Self-defence

So far, we have seen several ethical considerations that can justify a reluctance in wanting to eradicate mosquitoes. This reluctance may be based on a mosquito's moral standing, the natural historical value of a mosquito species, concerns about our own moral character or concerns about risk. In turn, these considerations will be part of a broader assessment of mosquito eradication proposals, most inclusively by providing a pluralistic picture that engages with different normative theories. Besides the virtue ethics approach mentioned above, one could ask questions about whether mosquitoes have certain rights that must be accounted for or whether certain strategies are better than others to maximize well-being. However, there is an additional dimension to dealing with mosquitoes not yet addressed. The question is what constitutes the appropriate problem-framing of the conflict between humans and disease-carrying mosquitoes and can it be framed as a matter of self-defence?[6]

Humans stand in a multitude of different moral relationships with non-human animals, each of which comes with a different set of moral demands. For example, most mosquito species do not prey on humans, a fact which makes living alongside them on a shared planet possible as long as human impact on their habitats, say in the forms of soil degradation or air pollution, is contained.[7] The case is different, however, for our relationship with those few mosquito species that "prey" on humans by having a preference for human blood. Yet, again only a subset of these anthropophilic mosquito species also carry malaria, dengue fever, Zika and so on.

At first glance, these cases of disease-carrying mosquitoes look like straightforward cases of self-defence which usually are considered morally permissible even if killing the aggressor is the only means to defend one's own life. For instance, self-defence could be a way of justifying the extermination of the smallpox pathogen, which was declared accomplished in 1979 (WHO 2019). Mosquitoes, like insects generally, have not featured prominently in the environmental ethics literature, but a self-defence framing stands out in this context. For instance, James Sterba has argued for a "Principle of Human Defense" which allows one to act against "harmful aggression" through harming and killing individual animals as well as *whole species*, when necessary (Sterba 2005: 295). This would cover the disease-carrying mosquito case and allow for their eradication despite the fact that Sterba, as a biocentrist, is committed to attributing moral standing to each individual mosquito. By analogy, if someone innocent was attacked by a human aggressor with a knife, we would judge violent self-defence permissible, with the human aggressor remaining a person with moral standing (see also Taylor 1986).

Indeed, Sterba explicitly mentions that killing disease-carrying mosquitoes is a justifiable act of self-defence and states the following:

> In the case of human aggression, however, it is sometimes possible to effectively defend oneself and other human beings by first suffering the aggression and then securing adequate compensation later. Because in the case of nonhuman aggression by the members of other species with which we are familiar, such an approach is unlikely to work, justifying more harmful preventive actions such as killing a rabid dog or *swatting a mosquito*, potentially carrying disease. There are simply more ways to effectively stop aggressive humans than there are to effectively stop aggressive nonhumans.
> *(Sterba 1998: 364, italics added)*

Sterba makes killing a mosquito, and in extension the eradication of a whole species, a bit more palatable by pointing out that in the case of mosquito "aggression" we do not have as many options of self-defence as we do with human conflicts. If someone vandalizes my house, I can demand compensation after the fact; but this is not the case for the mosquito who can place me in the hospital for months and neither can we "discuss" our differences in a conflict-resolution scenario. Yet, this does not necessarily allow any kind of self-defending actions because the question remains whether there are methods for protecting human health that are less harmful to mosquitoes whilst being effective enough, as mentioned above. For instance, Jake Monaghan argues that while a biocentric position allows for killing in self-defence, it demands "programs which make the mosquitoes malaria-resistant, if it is at all a possibility" (2018: 134). Of course, such programmes come with their own set of issues (particularly, when involving gene drives) that have to be taken into account. Moreover, for self-defence to be applicable, humans must apply "reasonable care" (Taylor 1986: 265) in avoiding contact with disease-carrying mosquitoes. Given the wide global spread of mosquitoes and the common use of disease-control measures (such as bed nets or protective clothing) this condition seems to be met in many instances.

Nevertheless, there is still some background missing from the mosquito story, namely that the mosquito is merely instrumentalized by the disease that it carries, the disease being the real "aggressor" from which we need self-defence. The real source of the problem is the microbe that produces malaria, dengue fever and Zika, with mosquitoes merely being the "vehicle" that transmits them. Accordingly, it is more apt to understand the disease-carrying mosquito as the "innocent" vector. The way we frame a problem determines what we identify as its morally relevant features and so the emphasis can be put on different aspects of the problem.

On the one hand, it can be seen as a clear case of (collective) self-defence where a large section of humanity justifiably tries to defend itself from an aggression against its health and lives. Excluding some forms of genetic modification (which would change the problem-framing), killing may be the only way to fend off such aggression if it comes from entities that are "innocent" in the sense of having no awareness of the consequences of their actions. The mosquito is not a moral agent. On the other hand, although all mosquitoes that feed on human

blood cause irritation, the dangerous "predator" that is targeted for eradication in this case is the disease (i.e. the virus or parasite) that they carry. So, one way of framing the issue would be to consider the eradication of the mosquitoes—now "innocent" by not being the ultimate source of the harm—as problematic "collateral damage" of the eradication of the diseases in question. That would be closer to a case of killing a bystander or hostage which carries a bigger moral burden. In a sense, the mosquito is "taken hostage" by the virus or the parasite that uses the mosquito's body as a resource. If that is an appropriate representation of the problem at hand, then it deviates in certain respects from the straightforward case of self-defence.

This illustrates, for one, that there are different senses in which the mosquito may be portrayed as "innocent." For instance, there is the unaware mosquito scenario and in that sense the mosquito constitutes an innocent threat. Yet, the mosquito also constitutes an innocent threat if it is instrumentalized by the virus which also does not constitute a moral agent. This is the hostage scenario, with an unaware virus. It follows that there are at least two ways in which the mosquito might constitute an innocent threat, and many might think that the second scenario intuitively requires more to be at stake to justify doing harm to the mosquito in fending off the disease. Although some might believe that self-defence against innocent threats is justified, others regard it as inappropriate to be conceived as self-defence, since the threat is innocent.[8] In that case, the problem would need to be framed as a matter of negative side-effects in the form of eradicating a species necessary for achieving the goal of a healthier world for people. That would mean that the human–mosquito conflict could not be framed as a matter of defence.

It therefore matters if the envisaged mosquito "specicide" is the outcome of a genuine self-defence scenario, or whether the mosquitoes are just bearing the burden of humanity's wish to make the Earth safer for itself, which includes a broad set of practices that affect the life and well-being of non-humans. Because there are alternatives to specicide when it comes to controlling mosquito-borne diseases, one must keep in mind that the eradication of the "innocent" mosquito cannot be disentangled from the broader web of potential moral failings. One needs to consider whether mosquito eradication proposals potentially constitute a means of obscuring other social and economic factors that can contribute to the prevalence of mosquito-borne diseases, such as the considerations of justice mentioned in the first section.[9] For instance, a focus on mosquito eradication might obscure that there are pressing social justice concerns such as about necessary access to health services that need to be addressed urgently. The swatting of a single mosquito that landed on my arm therefore needs to be distinguished from a practice of species eradication that is connected to a range of other moral and political decisions that depend on broader ethical considerations regarding humans and non-humans alike.

Of course, this discussion of "innocence" depends on the mosquito itself having moral standing, as discussed previously. Such considerations mean that a

disease-carrying mosquito is not equivalent to a virus-infected computer, for example. Any perspective that denies moral standing to mosquitoes will perceive the mosquito problem as less complex than presented here. Beyond the question of "innocence," another dimension of the mosquito problem considers the question of how far this scenario constitutes a matter of *self*-defence.

So far, we have simply framed defence as a collective self-defence in which "humanity" defends itself. In practice, there are considerable regional differences that are in the process of transformation due to climate change, with not all regions and communities being equally affected by mosquito-borne diseases. Some regions and some individuals are not affected at all while others must deal with several mosquito-borne diseases at once. More accurately would then be to frame it as a matter of self-defence of certain affected communities, if that is the course of action that they choose to pursue. Or, it could be framed as a third-party defence, because in practice such large-scale eradication programmes are instigated by national and international organizations in aid for the affected communities. As such the defence of others would generate additional issues to take into consideration in comparison to a straightforward case of self-defence (for instance, is there a duty to defend the affected party and, if so, by whom?). This question of agency therefore links, in turn, to broader questions of global health justice, such as regarding potential duties to finance mosquito interventions and technology transfer and reintroduces challenges of political legitimacy and informed consent.[10]

The upshot

As we have seen, whether the eradication of a mosquito species can be considered morally defensible depends on a range of normative and empirical questions. I have outlined how some of these considerations can be brought in the mosquito's favour. These may be based, inter alia, on the moral standing of individual mosquitoes, the moral value of a whole mosquito species, and concerns about hubris and risk.

Yet these considerations neither exhaust all that can be said from an environmental ethics perspective nor are they meant to deny the strong moral prerogative to reduce the health burden of mosquito-borne disease. That we have reached the point of even asking the question about whether mosquitoes should be eradicated, indicates that we must carefully consider its context to make sure that nothing of moral relevance is overlooked. For one, we need to ask whether, and in what form, the self-defence scenario is an appropriate problem-framing. Next, we must consider whether there are any alternative means which might be all-things-considered morally preferable. If alternatives to eradication are viable—and since the eradication of disease-carrying mosquitoes may be impossible—then part of the debate should be about whether there are moral demands, such as in terms of global justice, to fund alternative efforts to reduce diseases carried by mosquitoes and other vectors. It would also be valuable to take

a step back to think about how the mosquito question is the product of moral failures that have perpetuated the global problem of mosquito-borne diseases. Such considerations lead us also to political questions, such as vested interests in different technologies, which will influence which set of options are available.

Even if our answer is ultimately affirmative—that we do need to eradicate certain mosquito species to the best of our abilities—doing so still requires awareness that something of moral value will be lost (e.g. in terms of the species) and that something of moral status has potentially been harmed (that is, individual mosquitoes). The upshot is that taking all these moral considerations seriously will leave us with an awareness that the eradication of these species cannot be taken lightly. Any environmental ethics theory that dismisses such a loss oversimplifies the complex and conflictual moral decision-making at play, even when we have very good reasons to defend and protect our own health.

Notes

1 Of course, depending on how we define harm and the well-being of individual mosquitoes, it is not necessarily the case that all potential forms of eradication or control interventions would cause any harm to individuals. What constitutes harm to insects is an area of debate, but most generally, it seems that methods that kill adult mosquitoes are likely to involve harm to individuals while preventing them from coming to life in the first place does not.
2 But note that "ecosystem services" can also be understood more broadly, involving more than instrumental values only.
3 Most plausible to me, the non-instrumental moral value of species is not identical to the moral status of individuals as discussed in the last section (Sandler 2012), but that still leaves a range of options.
4 Non-instrumental value is often labelled as "intrinsic value" but for a nuanced differentiation between various uses of "intrinsic value" see O'Neill 1992.
5 Besides questions about which kinds of risk for humans (e.g. adverse ecological effects) and their likelihood we deem acceptable or not, gene-drive technology is also entangled in a host of other normative questions that I cannot do justice to here. See Preston and Wickson (2019) for a comprehensive overview. For instance, such technological interventions raise also questions about naturalness, the ontology of species and new responsibilities in light of changing relationships between humans and non-human beings. For example, accounts that consider "naturalness"—which is a contested concept (see Siipi 2008)—to confer a non-instrumental moral value might deem synthetic gene drives particularly problematic by introducing an "artificial" element into nature.
6 Ultimately, that is a matter of choice. Alternatives need to be considered and the appropriateness of the self-defence analogy can be challenged.
7 It has been argued that keeping environmental degradation to a minimum is even a matter of doing justice to non-human living beings. Yet, while the destruction of mosquito habitats is a matter of (distributive) justice, the conflict between disease-carrying mosquitoes and humans is not (Wienhues 2020).
8 For an overview of defence against animals see Kagan 2019. See also Monaghan (2018) for a biocentric argument that justifies self-defence against innocent threats.
9 Such concerns particularly apply to the employment of biotechnological means such as gene drives. See Preston and Wickson (2019).
10 An additional matter of third-party defence is the question of the affected domestic animals. Based on the idea that we are standing with domesticated animals in a

different relationship than with animals such as the mosquito (see Palmer 2010), it could be argued, for example, that the defence of domestic animals from mosquito-borne diseases is necessitated by a duty of care for these animals (of course, while putting aside questions about the moral legitimacy of animal husbandry in the first place).

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